California Renewable Diesel Multimedia Evaluation Tier I Report

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Biodiesel Workshop

Tom McKone, University of California, Berkeley
Tim Ginn, University of California, Davis
Dave Rice, Consultant to University of California

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Renewable Diesel Tier I Elements

- Background
- Study Approach—Life Cycle and Multimedia
- Release Scenarios
- Renewable Diesel Production, Storage, Distribution and Use
- Renewable Diesel Toxicity
- Transport and Fate
- Tier I Conclusions

Background

- **Currently the majority of biological-source diesel fuels are fatty-acid methyl esters (FAME)**
- **Renewable diesel is different and now entering the market**
- **According to the Low-Carbon Fuel Standard (LCFS)**

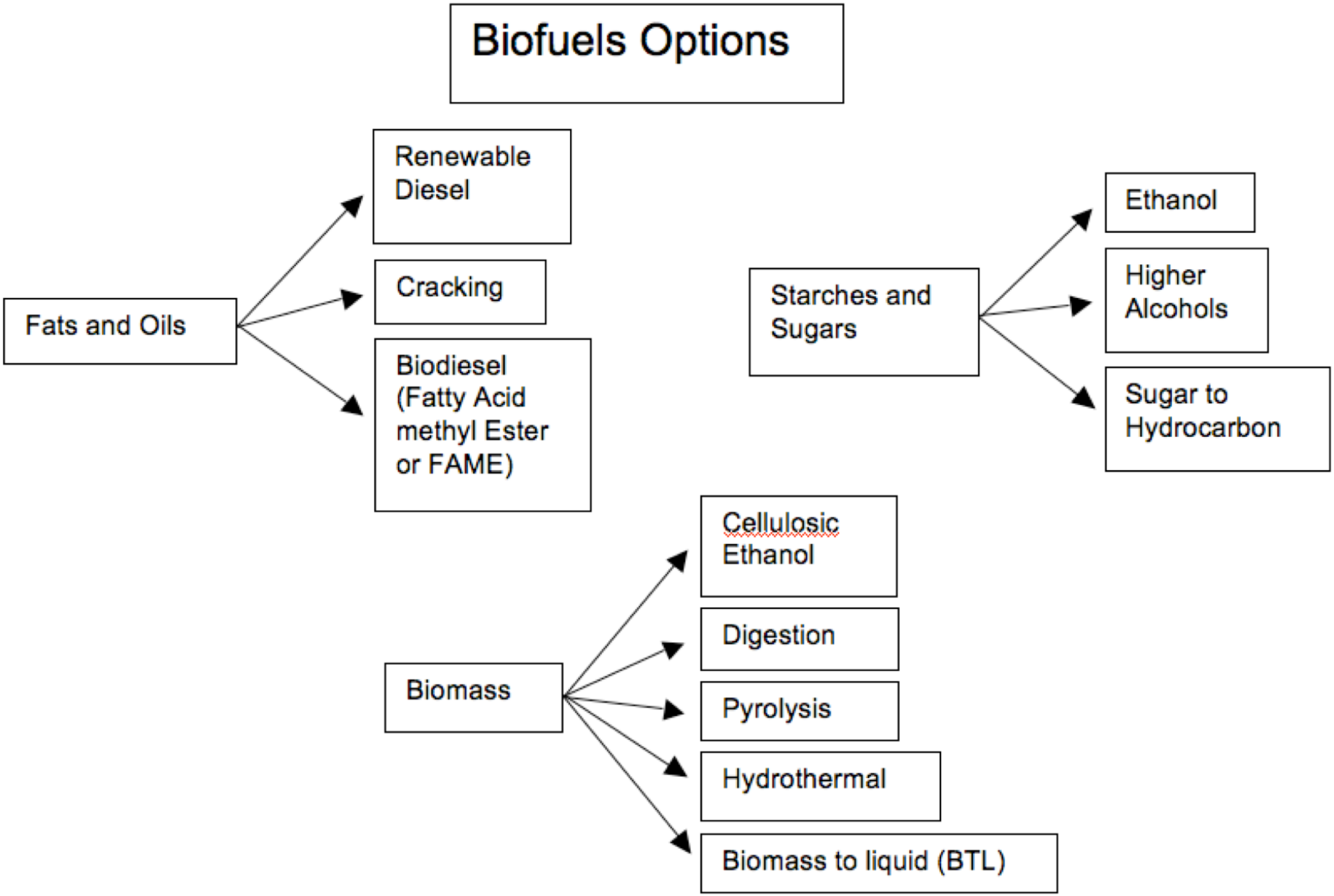
"… a motor vehicle fuel or fuel additive which is all the following:

(A) Registered as a motor vehicle fuel or fuel additive under 40 CFR part 79; A-9

(B) Not a mono-alkyl ester;

(C) Intended for use in engines that are designed to run on conventional diesel fuel; and

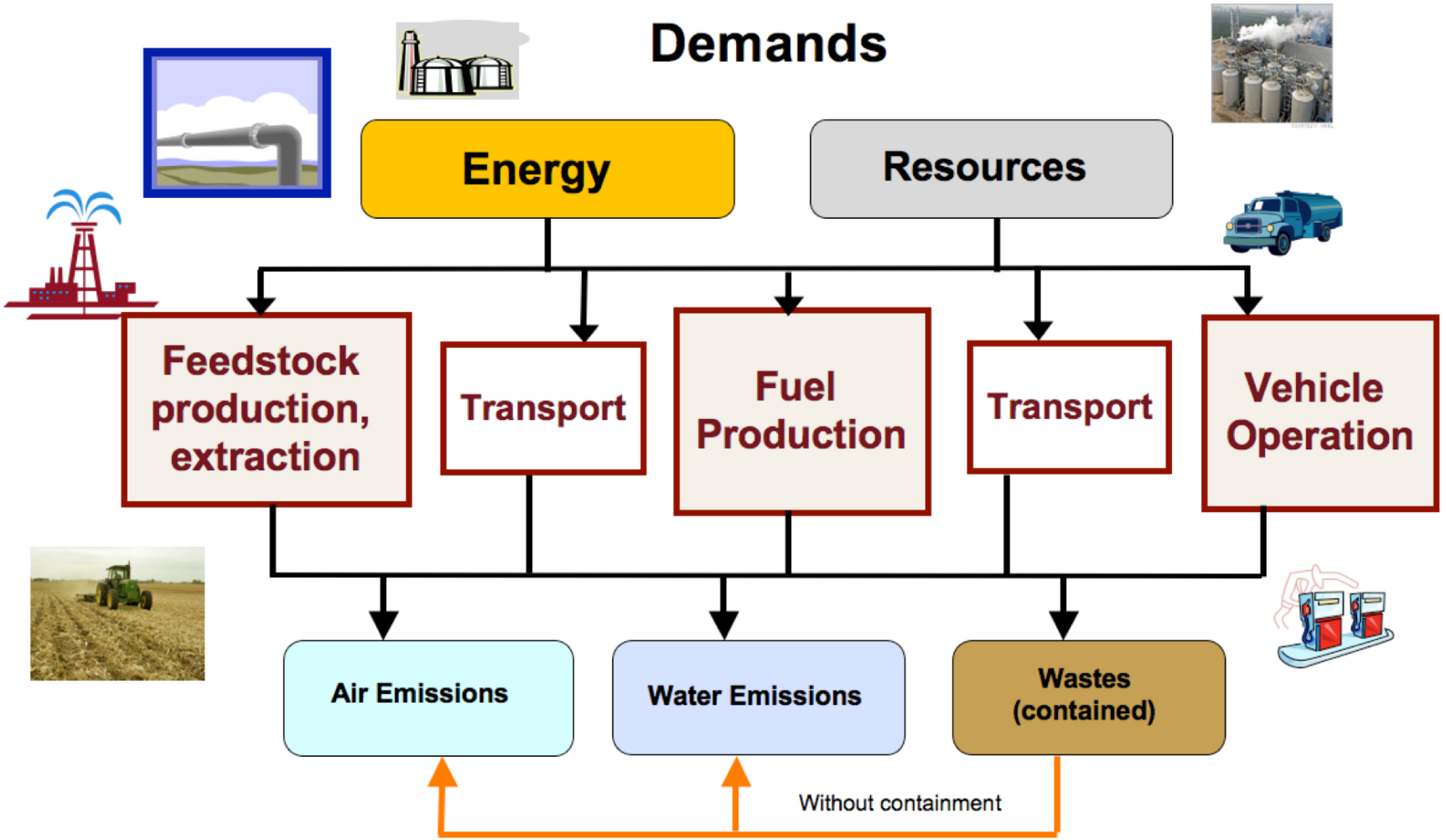
(D) Derived from nonpetroleum renewable resources."


Biofuels Options
Fats and Oils
Renewable Diesel
Cracking
Biodiesel (Fatty Acid methyl Ester or FAME)
Starches and Sugars
Ethanol
Higher Alcohols
Sugar to Hydrocarbon
Biomass
Cellulosic Ethanol
Digestion
Pyrolysis
Hydrothermal
Biomass to liquid (BTL)

Study Approach

- **Life-cycle approach to impacts**
  - Human health
  - Ecological risk
  - Resource stress and damage
- **Identify key uncertainties and data gaps**
- **Address multimedia impacts**
  - Air quality
  - Water resources
  - Soil
  - Infrastructure
- **Excludes indirect environmental, ecological, and health impacts from biomass production (i.e. climate disruption)**

Life-Cycle Stages



Key LCA Studies Review

- **US EPA Life Cycle Assessment of Renewable Fuels**
  - As part of its RFS2 rulemaking, EPA made a life cycle assessment of alternative and petroleum transportation fuels
  - EPA reported fuel use and production emissions
- **National Research Council "Hidden Costs of Energy" Study (2009)**
  - Life-cycle damage per vehicle-mile traveled (VMT)
  - Different combinations of fuels and vehicle technologies
  - VMT damages were remarkably similar
  - NRC urged caution interpreting small differences between fuel/vehicle combinations

Release Scenarios

- **Normal releases**
  - **Production emissions (in addition to refinery operation)**
    - Hexane or CO_2 released to the air during seed extraction,
    - Odors associated with waste biomass
    - Used process water discharges (pH and trace-chemicals)
  - **Use-phase (combustion) emissions**
    - Tailpipe emissions
    - Marine engine water releases
- **Off-normal releases—effectively the same as ULSD**
  - **Spills and leaks during production, distribution, and storage**
    - Above- or below-ground storage tank & associated piping,
    - Liquid-transportation vehicles--rail tank car, tanker truck, tanker ship
    - Bulk-fuel transport pipeline

Production, Distribution, Storage and Use

- **Approaches to producing renewable diesel (RD)**
  - **Hydrotreating vegetable oils or animal fats to make Hydrogenation Derived Renewable Diesel (HDRD)**
  - **Partially combusting a biomass to get CO/H_2 (syngas) utilizing the Fischer-Tropsch reaction to produce complex hydrocarbons**
  - **Emerging approaches based on synthesis of hydrocarbons through enzymatic reactions**
- **Producing HDRD**
  - **Co-processing in a conventional petroleum production stream**
  - **Dedicated HDRD (or R100) production with distribution, direct use or dilution**
- **Specifications for additives to RD expected to be similar to ULSD**

Production, Distribution, Storage and Use

- **Combustion emissions studies are ongoing**
- **Preliminary results suggest Renewable Diesel (RD) emissions & impacts that are within the range of ULSD emissions & impacts**
  - **Absence of sulfur and aromatic compounds in pure RD**
  - **Pure HDRD fuel showed significant emission benefits for CO, HC, NOx and PM—Secondary PM not yet addressed**
    Below 10% RD, blends can result in CO and HC reductions, but not PM, NOx
  - **Volumetric fuel consumption is 5% higher because of lower HDRD density**
  - **HDRD fuels avoid some biodiesel issues (oxidation, hygroscopicity, fouling, catalyst deactivation, etc).**

Toxicity

- **Key challenge**
  - RD is not a defined chemical formulation or a defined mixture of components
- **Limited tests indicate that RD has low relative toxicity**
  - Major differences in health and ecological impact between existing diesel and RD blends are more likely to be associated with additives than with the hydrocarbon mix
  - Chemical comparison to conventional diesel is important for determining whether or how much additional toxicity tests are required

Transport and Fate

- The fate and transport of a fuel and its component chemicals in the environment depend on the multimedia transport properties of its constituent chemicals
- Based on similarities in chemical composition, the multimedia environmental behavior of renewable diesel should be be similar to ULSD
- Impact of additives to fate and transport need to be evaluated

Tier I Conclusions

- Renewable diesel (RD) is chemically similar to the ultra-low sulfur diesel (ULSD) fuel already in wide use in California
- RD is compatible with existing refining and distribution infrastructure and can be used in current diesel engines without modification
- Pure renewable diesel has reduced aromatic hydrocarbon content
- Limited toxicity testing on rats reveals that pure RD has limited inherent toxicity and unlikely to exceed the inherent toxicity or mutagenicity of standard diesel.
- Life-cycle health impacts of renewable diesel blends are not likely to differ significantly from those of petroleum diesel.

Tier I Conclusions

- **Knowledge gaps include**
  - **Additive impacts**
  - **Production, storage and distribution releases (off-normal)**
  - **Air emissions toxicity testing**
  - **Priority list of renewable diesel fuel formulations**